

Original Research Paper

Design and Performance Testing of Seawater Batteries as Renewable Energy for Marine Boat Lights

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Abstract: Indonesian seas offer abundant renewable energy potential. Seawater batteries have attractive advantages as a source of electrical energy. The purpose of this study was to design and manufacture a seawater battery and test its performance for ship lighting. The methodology used includes designing and manufacturing a seawater battery storage container based on electrode dimensions, assembling electrodes and insulators, and testing battery performance using LED lights. The results showed that the design produced an 8-cell seawater battery with a height of 24 cm and a diameter of 17.78 cm (7 inches). Performance testing with a 7 W LED lamp for 60 minutes showed that higher salt content caused an increase in the average light intensity produced. In 8 W and 10 W LED lamps, it is known that an increase in the average light intensity produced only occurs at an increase in salt content of 3 to 4%, while an increase in the average light intensity at a salt content of 5% does not occur, iii) average salt content -an average of 4% on a seawater battery with a 60 minute test for a 7W LED lamp produces an average light intensity of 227.33 lumens, for an 8W LED lamp an average of 325 lumens, and for a 10W LED lamp an average of 604, 67 lumens. The greater the power of the LED lamp used, the greater the light intensity produced.

Keywords: Battery Design, LED Testing, Marine Lighting, Renewable Energy, Seawater Battery.



1. Introduction

Indonesia as an archipelagic country has vast seas. Apart from being a source of food, Indonesia's seas provide an abundant source of new and renewable energy when energy sourced from fossil fuels is running low [1]. One use of sea water as an energy source is sea water batteries for boat lights. Apart from being used for lighting at night, this lamp can also be used as a fishing aid [2][3]. Seawater batteries have attractive advantages as a source of electrical energy, namely that they are relatively inexpensive to manufacture, easy to operate and easy to transport [4].

Seawater batteries work based on the working principle of Galvanic cells. Galvanic cells are cells that produce electric current through electrochemical reactions. Galvanic cells are composed of anode, cathode and electrolyte [5]. Electrochemical reactions occur because there is a potential difference between electrodes and chemical reactions occur spontaneously. At the cathode a reduction reaction occurs, while at the anode an oxidation reaction occurs which produces electrons [6].

This study focuses on the design and performance testing of seawater batteries for boat lighting. It highlights the relationship between salinity levels and light intensity. The study explores these factors in detail to understand their impact on battery performance. The findings aim to contribute to the development of efficient and sustainable energy solutions for maritime applications. Seawater batteries have the potential to provide an environmentally friendly alternative to conventional energy sources.

2. Literature Review

A battery is a device that can convert the chemical energy contained in the material directly into electrical energy through redox electrochemical reactions [7]. Cells are the basic electrochemical elements for energy storage. The main components of a battery are electrodes, electrolytes, terminals, separators, and their places. A battery has two electrodes, an anode and a cathode, where the anode is the positive electrode and the cathode is the negative electrode. A potential difference is generated between the anode and the cathode. When two electrodes are connected across a load, current flows from the cathode to the anode. The oxidation reaction takes place at the anode, and the reduction reaction takes place at the cathode. Electrolytes are substances contained in batteries. The material present in the anode and cathode reacts chemically with the material and this reaction produces electrical energy. The connection is where the positive and negative terminals on the battery cover are. All battery components and electrolytes are placed in the case [8] - [13].

Seawater batteries directly use seawater as an electrolyte, thereby providing a new strategy for electricity supply and energy storage in marine environments. As a type of natural salt solution that has abundant reserves (70% of the earth's surface area), sea water meets electrolyte needs in an era of energy and environmental crises [14]. Obtaining energy from renewable natural resources has attracted great attention due to their abundance and sustainability. Sea water is a readily available natural resource, abundant on earth. The battery can be activated by using seawater as an electrolyte source. These batteries are safe and offer high power density, stable voltage, high specific energy and long dry storage life and are widely used in marine exploration instruments, life-saving equipment and underwater weaponry [15].

In this seawater battery concept, the seawater electrolyte is reacted with a copper (Cu) electrode as the anode and a zinc (Zn) electrode, as the cathode. The anode is where the oxidation reaction takes place. Oxidation reactions are reactions that increase the oxidation number by releasing or adding oxygen to molecules, atoms, or ions. This reaction occurs with copper (Cu). The cathode is where the reduction reaction takes place. A reduction reaction is a reaction in which the oxidation number is reduced due to the gain of electrons or the release of oxygen in the molecule, and the ion in this reaction occurs in zinc (Zn). The reaction of battery elements (electrodes and electrolyte) can be used as alternative renewable energy using the voltaic battery method. Voltaic batteries are electrochemical batteries in which chemical energy is spontaneously converted into electrical energy (Redox Reaction). The operating principle of a voltaic cell in generating current is that the current transfers electrons from the oxidation reaction at the anode to the reduction reaction at the cathode through an external circuit [15] - [16].

Fishing activities that use seawater batteries with common electrodes such as Al-Cu, Zn-Cu, Gal-Cu are expected to be used in selecting the application of fixed lift nets through the innovation of Light Emitting Diode (LED) fishing lights. In the research that has been carried out, the performance of seawater batteries with various common electrodes to light LED lights during the discharge process

was evaluated. Measurement of the potential and output current of aluminum (Al), zinc (Zn), and galvalum (Gal) seawater battery anodes without load and under load conditions. The results showed zinc the anode has higher performance in terms of output voltage and current compared to galvalum anode and aluminum anode. Maximum zinc power output (704.17 mW) is not significantly different from galvalum (726.41 mW), but has a significant difference, significantly different from aluminum (175.75 mW). This is good evidence that seawater battery performance is affected by the anode material. Zinc and galvalume are sufficient to be developed as seawater battery anodes because they contain higher amounts of potential, current and output power [17].

Electrical energy is used to drive non-spontaneous redox reactions in electrolyte battery cells, which consist of electrochemical cells. An electrochemical cell consists of an electrolyte and electrodes. Water or other solvents are usually used to make electrolytes, which are solutions containing dissolved ions. The aim of the research that has been carried out is to test, analyze, and build electrochemical cell batteries using various electrolyte solutions, salt water concentrations, and cell and electrode integration. The design focuses on finding the optimal electrode combination limited to zinc, copper, and aluminum (soda cans), different electrolytes, cell junction types, and different salt solution concentrations used to produce optimal energy output. The research results show an average voltage of 0.705 V per cell produced by the zinc-copper electrode. The most effective results are provided by salt water electrolytes. A 30% concentration of salt solution produces optimal voltage, and the cell connection in series is the best. Using these parameters, 20 cells were built that produce 14.1 V without load. Using a 12 V lamp load produces a voltage of 7.57 V and a current of 1.1 A [18].

In fishing activities, especially at night, fishermen use lights to attract fish so that fishing opportunities are greater. However, fishermen need an electricity supply to turn on the lights when at sea. Fishermen usually use batteries. The research that has been carried out aims to utilize sea water as an alternative energy source to overcome the problem of high operational costs for fishermen. In the research was carried out using two electrodes (zinc and copper) that were placed vertically in a container and then filled with sea water. The two electrodes are connected in series, producing a high output voltage to light the LED. After initial measurements, the resulting output voltage is 5V and can light up the LED with quite a bright light. In regular measurements for 96 hours with data collection every 4 hours, voltage, current and power did not experience a significant decrease, so seawater lamps are suitable for use by coastal communities and fishermen as lighting when going to sea at night. The results of the research that has been carried out can become an alternative and renewable energy source that can be widely utilized [19].

Research has been carried out to evaluate the electrochemical performance of galvanic cells that use seawater as an electrolyte. The cell has a volume of 200 mL which is equipped with zinc metal as the anode and silver-coated copper metal as the cathode (Cu(Ag)-Zn) to suppress copper corrosion. For comparison, the same experiment was also carried out using uncoated copper as the cathode (Cu-Zn). A system containing 20 cells connected in series in a closed container filled with seawater. The experiment was carried out for 72 hours, by changing the sea water every 24 hours. Open circuit voltage, closed circuit voltage, current, light intensity, internal resistance, and power are evaluations of system performance. The experimental results show the better performance of Cu(Ag)-Zn which is caused by the much lower corrosion rate of the Cu(Ag) cathode which shows the role of the Ag layer in protecting Cu from seawater. Cu(Ag)-Zn maintains the cathode corrosion rate with a ratio of 0.19. The percentage reduction in Cu(Ag)-Zn open circuit voltage was 6.14%, third-day closed circuit voltage was 0.99%, current was 36.68%, and power was 37.83% [20].

3. Methodology

The methodology used includes:

- 1) Design and make a seawater battery storage container based on the size of the electrode.
- 2) Assemble the electrodes and insulators.
- 3) Test the performance of the seawater battery using LED lights with a fluxmeter.

In this research, the author limited the problem by focusing on testing the intensity of light on seawater batteries using 7 W, 8 W, and 10 W LED lamps which were tested on seawater batteries that had 8 cells and used Copper (Cu) and Zinc electrodes (Zn) with an electrode size of 10 cm x 30 cm, each with a thickness of 0.2 mm for 60 minutes with a salt content of 3%, 4% and 5% [21].

4. Finding and Discussion

Figure 1 shows the results of the design and testing using LED lights.



Figure 1. Results of Design and Testing using LED Lights

In this research, the light intensity produced by a salt water battery which has 8 cells with copper electrodes measuring 10 cm x 30 cm and zinc 10 cm x 30 cm will be tested on 7 W, 8 W, and 10 W lamps. The results of the tests that have been carried out can be seen in Figure 2.

After 60 minutes of testing on a 7 W lamp with seawater batteries: A salt content of 3% produces an average light intensity of 167 Lumen. A salt content of 4% produces an average light intensity of 257 Lumen. A salt content of 5% produces an average light intensity of 258 Lumen.

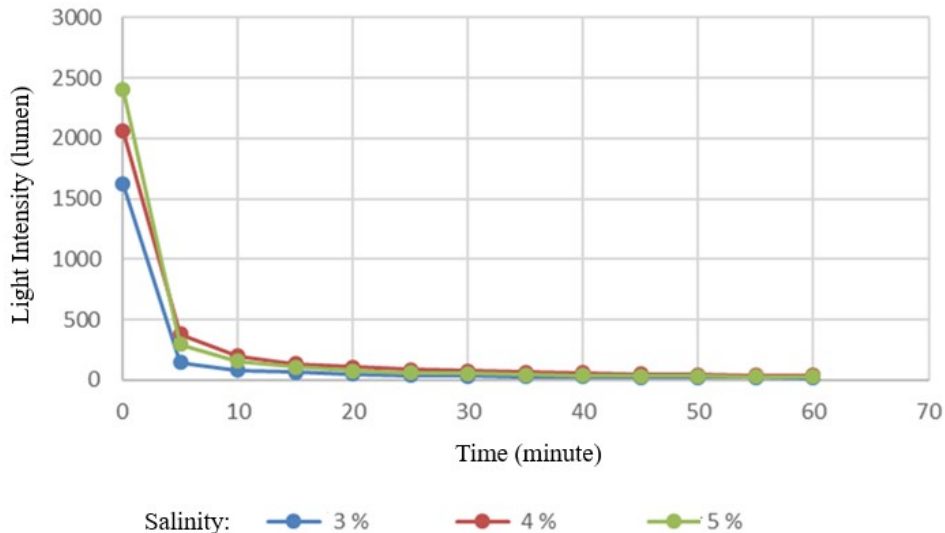


Figure 2. Testing on 7 W LED Lamp

After 60 minutes of testing on an 8 W lamp with seawater batteries: A salt content of 3% produces an average light intensity of 298 Lumen. A salt content of 4% produces an average light intensity of 361 Lumen. A salt content of 5% produces an average light intensity of 316 Lumen.

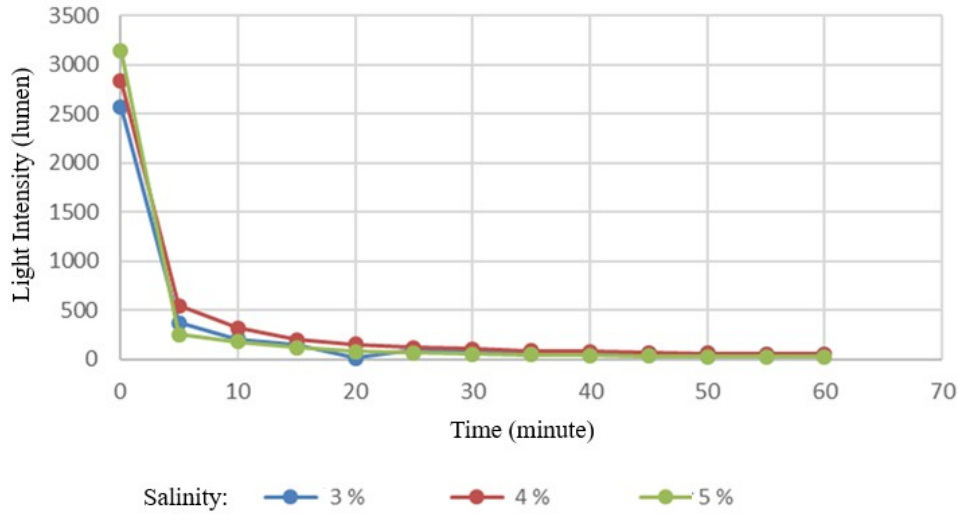


Figure 3. Testing on 8 W LED Lamp

After 60 minutes of testing on a 10 W lamp with seawater batteries: A salt content of 3% produces an average light intensity of 468 Lumen. A salt content of 4% produces an average light intensity of 679 Lumen. A salt content of 5% produces an average light intensity of 667 Lumen.

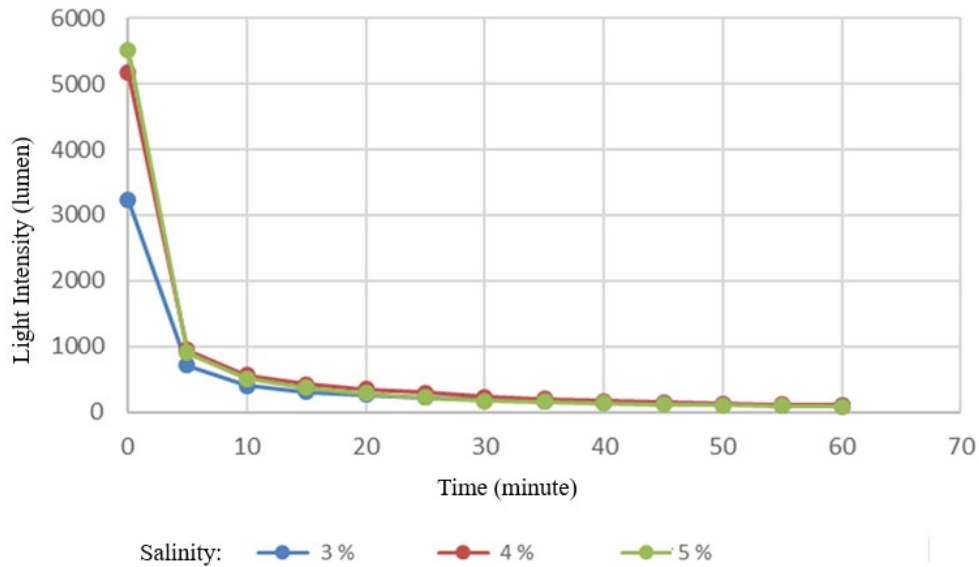


Figure 4. Testing on 10 W LED lamp

The discussion of this study focuses on the performance of seawater batteries with varying salt levels when tested on LED lamps with different power (7 W, 8 W, and 10 W). The results show that the light intensity produced is greatly influenced by the salt concentration in the seawater battery and the lamp power. Table 1 summarizes the results of the study.

Table 1 shows the relationship between the salt content in the seawater battery, the LED light power, and the light intensity produced after 60 minutes of testing.

Table 1. Relationship Between the Salt Content in the Seawater Battery

Lamp Wattage	Salt Content (%)	Average Light Intensity (Lumen)
7 W	3%	167
	4%	257
	5%	258
8 W	3%	298
	4%	361
	5%	316
10 W	3%	468
	4%	679
	5%	667

For the 7 W lamp, the light intensity increases with higher salt levels, reaching a maximum of 258 Lumen at a salt concentration of 5%. However, the difference between 4% and 5% salt levels is very small, indicating a potential saturation point where further increases in salt levels do not significantly improve performance.

For the 8 W lamp, the highest light intensity of 361 Lumen was observed at a salt concentration of 4%, with a slight decrease at a salt content of 5% (316 Lumen). This suggests that above a certain concentration, battery performance may decrease due to potential inefficiencies such as electrode polarization or ionic saturation.

The most pronounced effect is seen in the 10 W lamp, where the light intensity peaks at 679 Lumen at a salt concentration of 4%. Similar to the 8 W lamp, a slight decrease was observed at 5% salt content (667 Lumens), reinforcing the idea of an optimal salinity level for maximum performance.

Overall, these findings suggest that while increasing salt content generally increases light intensity, there is a limit beyond which performance can decline. Furthermore, higher-wattage lamps produce greater light intensity but may also require optimization of the battery design to maintain efficient performance. These insights are important for improving the practical applications of seawater batteries, particularly in marine environments where salt water is present.

5. Conclusion

Based on the results and discussion, it can be concluded that the design carried out produces a seawater battery with a total of 8 cells with a height of 24 cm and a diameter of 17.78 cm (7 inches). Test results on a seawater battery for 60 minutes with a 7 W LED lamp showed that the higher the salt content, the higher the average light intensity produced. In 8 W and 10 W LED lamps, it was found that the increase in the average light intensity produced only occurred at an increase in salt content of 3 to 4%, while an increase in average light intensity at a salt content of 5% did not occur. The average salt content of 4% in seawater batteries with a 60 minutes test for a 7W LED lamp produces an average light intensity of 227.33 lumens, for an 8W LED lamp it is 325 lumens, and for a 10W LED lamp, it is 604. 67 lumens. The greater the power of the LED lamp used, the greater the light intensity produced.

In further research, it is better to collect data over a longer time to find out how many hours it takes to exhaust the intensity of light produced. In addition, using more variations of LED lights.

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